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(54) Hemostatic bi-polar electrosurgical cutting apparatus

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Description

This invention relates to improved hemostatic electrosurgical instruments, and particularly to improved bipolar electrosurgical instruments for severing and causing hemostasis of tissue.

The control of bleeding during surgery accounts for a major portion of the time involved in an operation. In particular, bleeding that occurs when tissue is incised or severed can obscure the surgeon's vision, prolong the operation, and adversely effect the precision of cutting. Blood loss from surgical cutting may require blood infusion, thereby increasing the risk of harm to the patient.

Hemostatic surgical techniques are known for reducing the bleeding from incised tissue prior to, during, and subsequent to incision. One such technique uses a heating element to transfer heat to the severed tissue to thermally reform collagen. Heat transferred from the instrument to the tissue produces a thin collagenous film which seals over the severed blood vessels and capillaries, thus reducing bleeding. Localized application of heat reduces tissue necrosis or damage that may retard healing.

Electrosurgical techniques that pass a high frequency or radio frequency current through the patient's tissue between two electrodes for both cutting and causing hemostasis tissue also are known. The current passing through the tissue causes joulean (ohmic) heating of the tissue as a function of the current density and the resistance of the tissue through which the current passes. Such heating denatures the tissue proteins to form a coagulum that seals the bleeding sites.

Monopolar electrosurgical devices employ a small electrode at the end of a handle in the surgeon's hand and a large electrode plate beneath and in contact with the patient. Only one of the two electrodes required to complete the electrical circuit is manipulated by the surgeon and placed on or near the tissue being operated on. The other electrode is the large plate beneath the patient. The electrosurgery power supply impresses high frequency voltage spikes of thousands of volts between these two electrodes, sufficient to cause electric arcing from the small operating electrode the surgeon holds to the most proximate tissues, then through the patient to the large electrode plate beneath the patient. In the patient, the electrical current becomes converted to heat; hottest in the tissues immediately below the small hand-held electrode where the currents are most concentrated.

A principal disadvantage of monopolar electrocautery is that current flows completely through the patient. These high voltage electrical currents may arc from the small electrode to nearby non-targeted vital structures, or follow erratic paths as they flow through the patient's body, thus causing damage to tissues both near and at some distance from the electrode.

Another drawback of monopolar electrosurgical devices is the excessive tissue damage caused by the high voltage arc, including carbonization of the tissue,

which compromises wound healing. Furthermore, monopolar devices typically create vision obscuring smoke, which must be evacuated from the surgical site.

In bipolar electrosurgical devices, two electrodes are closely spaced together and have the same surface area in contact with the tissue. The current flow is thus locally confined to the tissue that is disposed between and electrically connects the electrodes.

One difficulty encountered with prior art electrosurgical devices is that of controlling the current flow through the patient's tissue to obtain hemostasis in localized areas, without also heating and causing undesirable trauma to adjacent tissue. Although the introduction of bipolar electrosurgical devices has helped to localize current flow, previously known bipolar electrosurgical devices present difficulties in selectively applying the current flow.

For example, US-A-3,651,811 and SU-A-575,103 describe bipolar electrosurgical scissors having opposing cutting blades forming active electrodes. These devices enable a surgeon to sequentially coagulate the blood vessels contained in the tissue and then mechanically sever the tissue with the scissor blades. However, these devices apparently require the surgeon to cycle the power supplied to the electrodes during separate steps of obtaining hemostasis in the tissue and then cutting the tissue. In particular, these previously known devices require the surgeon to first energize the electrodes and grasp the tissue to cause hemostasis. Once the blood vessels contained within the tissue are coagulated, the electrodes are deenergized so that the scissor blades may be closed completely to sever the tissue mechanically. The scissors are then repositioned for another cut, and the power supply to the scissors cycled on and off again to congeal the tissue. Neither of these devices appear to permit the surgeon to maintain the electrodes in a continuously energized state, because the power supply would be shorted out or damaged if the blades were permitted to contact each other while energized.

Accordingly, a major drawback of previously known hemostatic bipolar electrosurgical cutting devices is that they have neither recognized the existence of, nor resolved the problem of, selectively delivering a current to obtain hemostasis at one location in the tissue, while simultaneously allowing already hemostatically heated tissue to be severed. It would therefore be desirable to provide a bipolar electrosurgical instrument that automatically and continuously adjusts the current delivery location so that it precedes the cutting point, without shorting the electrodes and interrupting the current providing hemostasis of the tissue.

Another drawback of previously known bipolar electrosurgical devices is the tendency for coagulum to build up on the electrode surfaces. Such buildup may impede the cutting ability of the device, cause sticking of the tissue to the device, and interfere with the surgeon's ability to manipulate the device at the surgical site.

Another related drawback is the tendency in previously known bipolar electrosurgical devices to experience some current leakage near the electrodes, which may result in coagulum buildup on the non-active surfaces of the electrosurgical instrument as well.

It would therefore be desirable to provide an electrosurgical instrument wherein coagulum buildup on the surfaces of the instrument is reduced, thereby improving maneuverability of the instrument at the surgical site and reducing trauma to adjacent tissue.

Heretofore, no bipolar electrosurgical instrument for cutting and causing hemostasis of planar tissue areas has recognized or overcome the aforementioned problems. A continuing need for improved hemostatic electrosurgical scissors-like devices for simultaneously causing hemostasis in tissue and severing that tissue therefore exists.

In view of the foregoing, it is an object of the present invention to provide a bipolar electrosurgical scissors-like cutting instrument which simultaneously causes hemostasis of tissue and mechanically severs tissue in a continuous manner at a cutting point that advances along the cutting edges of the scissor members.

It is another object of the present invention to provide an electrosurgical scissors-like cutting instrument that eliminates the need for the surgeon to energize and deenergize the electrodes of the scissor members during the steps of causing hemostasis of the tissue and mechanically severing the tissue. The instrument constructed in accordance with the principles of this invention therefore reduces the likelihood that the electrodes may short circuit during cutting, thus permitting the instrument to be used for continuously hemostatically cutting tissue. The result is an instrument providing a smoother and more precise surgical cut than previously known devices, which permit hemostasis and cutting of discrete tissue sections in an intermittent, non-continuous, manner.

It is yet another object of the present invention to provide improved hemostatic electrosurgical scissors that reduce coagulum buildup and adherence of tissue to the working and non-working surfaces of the instrument.

These objects are solved with the features of the claims.

The exemplary methods for hemostatically severing tissue with an electrosurgical instrument, reduce the number of steps required of the surgeon to employ the electrosurgical instrument in a continuous manner.

The methods described use electrosurgical instruments that reduce coagulum buildup and sticking of tissue to the surfaces of the instrument.

These and other objects are accomplished in accordance with the principles of the present invention by providing a bipolar electrosurgical scissors-like instrument wherein each scissor member comprises an electrode for causing hemostasis of tissue and a shearing surface for mechanically severing the tissue. A layer of insulating material is disposed on at least one shearing surface of the scissors so that the electrically active por-

tions of the scissor members do not contact each other at any point during operation of the instrument. Thus, current flows through tissue between the scissor members, but short circuits -- which would terminate hemostasis -- do not occur. With this arrangement, hemostasis and cutting occurs in a continuous manner along tissue disposed between the scissor blades.

In particular, an electrosurgical instrument constructed in accordance with the present invention comprises a scissors-like instrument including first and second scissor members. Each scissor member comprises a blade-like portion or shearing member having a shearing surface, a cutting edge and an exterior surface. The first and second scissor members are connected by connecting means so that the respective shearing surfaces move through a range of motion in a conventional scissors-like cutting action. That cutting action defines a cutting point that moves along the cutting edges of the respective shearing members through the range of motion, as is known. The instrument of the present invention further includes an electrode on each shearing member which is connected to a power supply that provides a high frequency current. An electrically insulating material is interposed between the electrodes so that the electrodes on the respective shearing members do not contact each other in the range of motion. The insulating material is disposed so that current passes between the electrodes of the respective shearing members distal to the cutting point, but not between the shearing surfaces.

In a first family of embodiments of the present invention, the first and second shearing members are made of an electrically conducting material so that they comprise, respectively, first and second electrodes. A first layer of electrically insulating material is disposed on at least one of the shearing surfaces, thereby forming the cutting edge and shearing surface of that shearing member. In these embodiments, the connecting means includes an electrically insulating material so that the shearing members are electrically isolated at the connecting means. The first layer of insulating material, whether disposed on one or both shearing surfaces, has a total thickness in the range of 0.050 to 1.270 mm (0.002 to 0.050 inches), and preferably in the range of 0.076 to 0.178 mm (0.003 to .007 inches).

To further achieve the advantages of the present invention, individual instruments of the first family of embodiments may include one or more of the following: a layer of material having a high electrical and thermal conductivity on one or both of the exterior surfaces of the shearing members; a second layer of insulating material disposed on the exterior surfaces of the shearing members, except for regions proximate the cutting edges; and a layer of abherent material disposed on the outermost tissue contacting portions of the instrument. These layers reduce coagulum buildup on the non-working surfaces of scissors, thereby reducing sticking and trauma to adjacent tissue. They also improve maneuverability of the instrument and enhance the surgeon's view of field, thereby enabling more precise surgical cutting.

A self-sharpening feature can be attained by employing a first layer of a first hardness on one of the shearing surfaces and a second layer of a second different hardness on the other shearing surface. Advantageously, the use of a harder material as one of the shearing surfaces provides for obtaining excellently mated cutting edges after a few cycles of operation and keeps the cutting edges sharp during repeated use.

In a second family of embodiments of the present invention, the first and second shearing members are made of a non-electrically conducting material, and the electrodes comprise a layer of electrically conducting material disposed on the exterior surfaces of each shearing member. In this arrangement, the electrically insulating material is comprised of the shearing members. The electrically conductive layers of the respective shearing members are spaced apart, at the cutting point, a distance in the range of from 0.050 to 1.270 mm (0.002 to 0.050 inches), preferably 0.076 to 0.178 mm (0.003 to 0.007 inches), as the cutting point moves through the range of motion. The layer of electrically conducting material on each shearing member may be comprised of an inner layer of a high electrical and thermal conductivity material and an outer layer of an oxidation resistant, high electrical and thermal conductivity material, the outer layer being superimposed in electrical contact over the inner layer.

Individual variations on instruments within the second family of embodiments may include an adherent layer covering the electrically conductive layer and a layer of electrically insulating material covering all of the electrically conductive layer except for a region of each shearing member proximate the cutting edge.

Exemplary methods are also provided for using bipolar electrosurgical instruments to simultaneously cause hemostasis in tissue while mechanically severing that tissue in a continuous manner, and without significant coagulum buildup or sticking. These methods include the steps of

- (a) providing first and second shearing members, each shearing member having a shearing surface, a cutting edge and an electrode, the shearing members connected together so that the shearing surfaces move in opposition through a range of motion in a scissors-like action that defines a cutting point moving along the cutting edges through the range of motion;
- (b) connecting the electrodes to a power supply;
- (c) selecting and maintaining a substantially constant voltage level output across the power supply, the voltage level output independent of the impedance of the load connected across the power supply;
- (d) providing an electrically insulating material between the first and second electrodes so that the electrodes do not contact each other in the range of motion;
- (e) placing the electrodes in electrical contact with tissue to be cut so that high frequency current

passes between the electrodes and through the tissue distal to the cutting point, but not between the shearing surfaces; and

(f) moving the first and second shearing members through the range of motion, thereby passing current through the tissue in a region distal to the cutting point, simultaneously causing hemostasis of the tissue and cutting the tissue at the cutting point.

10 The methods as described include selecting suitable voltage and current ranges for employing the present invention. The methods further include the use of alternating current voltage waveforms having a crest factor - ratio of peak voltage to root-mean-square (RMS) voltage - near unity.

15 The above and other objects and advantages of the invention will be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference numerals refer to like parts throughout, and in which:

20 FIG. 1 is an elevation perspective view of a scissors constructed in accordance with a typical one of a family of embodiments of the present invention; FIG. 2 is a side view of the scissors of FIG. 1, showing tissue disposed between the shearing members; FIG. 3 is a cross-sectional view taken along line 3-25 3 of FIG. 2; FIGS. 4-8 are cross-sectional views similar to that of FIG. 2 for various alternative embodiments of the present invention.

25 Referring to FIGS. 1-3, bipolar electrosurgical scissors 10 for simultaneously causing hemostasis in and shearing a patient's tissue 100 are described. Scissors 10 includes first scissor half 20 and second scissor half 30 pivotally connected by fastener 40. In a first family of embodiments constructed in accordance with present invention, scissor half 20 is made of an electrically conducting material and has at one end a first shearing member 21. Shearing member 21 forms a first electrode comprising shearing surface 22, cutting edge 23 and exterior surface 24. Scissor half 20 has, at the other end, support member 25, preferably configured with a thumb or finger hole for manipulating scissor half 20, and electrical connection 26 which connects the electrode to a conventional constant voltage power supply 10 via cable 27. Scissor half 30 is likewise made of an electrically conducting material and has at one end shearing member 31. Shearing member 31 forms a second electrode comprising shearing surface 32, cutting edge 33 and exterior surface 34. Scissor half 30 also has, at the other end, support member 35, preferably configured with a thumb or finger hole for manipulating scissor half 30, and electrical connection 36 which connects to power supply 110 via cable 37.

30 35 40 45 50 55 Power supply 110 may be a high frequency voltage source having a substantially constant voltage at selectable output levels. Such devices are described, for

example, in U.S. Patent Nos. 4,092,986 and 4,969,885. The power supply used in conjunction with the present invention preferably provides an output voltage level that is substantially constant at the user selected level, and independent of the electrical resistance encountered by the electrodes.

To reduce coagulum buildup on the working surfaces of the scissors, applicant has developed power supplies providing substantially constant voltage output that is independent of the load impedance, and have low source impedance and an alternating-current voltage waveform having a crest factor -- the ratio of peak voltage to RMS voltage -- near unity. The present invention, when powered by such power supplies, has been observed to provide highly satisfactory hemostasis without arcing or charring of the tissue, and little coagulum buildup.

Scissor halves 20 and 30 are preferably made of a rigid, structural material capable of sustaining sharp scissors-like cutting edges 23 and 33, such as stainless steel or martensitic stainless steel. Alternatively, materials of high electrical and thermal conductivity, and structurally strong enough for shearing tissue, such as copper or copper alloys, may be used. Halves 20 and 30 are pivotally connected by fastener 40 in opposition so that shearing surfaces 22 and 32 and cutting edges 23 and 33 of the shearing members move in scissors-like opposition through a range of motion to sever tissue 100 placed therebetween.

Fastener 40 may be, for example, a screw or a rivet that electrically insulates scissor halves 20 and 30 at the pivot point. The fastener may be made of an insulating material, for example, polyamide or nylon. Alternatively, fastener 40 may comprise a combination of non-insulating and insulating materials, such as a stainless steel screw insulated from one or both scissor halves 20 and 30 by nylon bushings.

Scissor support members 25 and 35 have insulating coating 11 in regions L₁ to electrically insulate the support members from each other and from the surgeon using scissors 10. Insulating coating 11, which may comprise polyvinyl chloride, nylon, or other plastic insulating material, also may be applied to those areas of scissors 10 not used for cutting tissue.

As illustrated in FIG. 3, exterior surfaces 24 and 34 of the shearing members may have a coating 12 of a high electrical and thermal conductivity material, e.g., silver or copper, other than on their respective shearing surfaces 22 and 32. Coating 12 facilitates good electrical contact between exterior surfaces 24 and 34 and the tissue that comes into contact with those surfaces as shearing members 21 and 31 are moved relative to one another.

Coating 12 reduces localized heating of the exterior surfaces 24 and 34 of shearing members 21 and 31 by dissipating the heat throughout the thermally conducting surface area of the coating. Coating 12 also reduces the likelihood that joulean heating of shearing members 21 and 31 will occur, because any localized current flow is re-distributed over the entire coating 12. Consequently,

coating 12 reduces thermal decomposition and sticking of blood and tissue to exterior surfaces 24 and 34 of scissors 10 during use.

5 A thin coating 13 of an electrically insulating material is disposed on each of shearing surfaces 22 and 32 to cover at least as much of those shearing surfaces as could contact each other within the full range of motion of scissor halves 20 and 30. Insulating coating 13 covers cutting edges 23 and 33 so that the cutting edges are electrically inactive and non-conducting.

10 As shown in FIG. 4, an alternative embodiment provides insulating coating 13 only on shearing surface 32 of shearing member 31. The other shearing surface 21 and cutting edge 23 remain electrically active, i.e., conductive. In this embodiment, electrical isolation between scissor halves 20 and 30 is achieved by the single layer of insulating material.

15 Insulating coating 13 allows the scissor halves forming the bipolar electrodes to move relative to each other so that current flows between exterior surface 24 of shearing member 21 and exterior surface 34 of shearing member 31, while ensuring that scissor halves 20 and 30 do not electrically contact each other. This configuration enables the cutting edges to contact each other to sever tissue while preventing short circuiting, which would impede simultaneous coagulation of the blood vessels extending through the tissue. Coating 13 substantially prevents current flow directly between opposing shearing surfaces 22 and 32 when the scissor halves are closed together. Rather, the current flows through the path of least resistance between the electrodes, i.e., through the tissue in direct contact with regions 28 and 38, respectively, of exterior surfaces 24 and 34 of the shearing members. This current flow is represented schematically by flux lines 99 shown in FIGS. 3 and 4.

20 The arrangement of the present invention confines current flow between regions 28 and 38 of exterior surfaces 24 and 34 to region 101 (see FIG. 2), from where cutting edges 23 and 33 contact each other to a point distal to the cutting point. That distal point is where either the tissue no longer forms an electrical connection between the electrode surfaces (region 102 of FIG. 2) or the spacing between halves 20 and 30 is sufficiently large that the current density is too low to cause significant joulean heating of the tissue (region 103 of FIG. 2).

25 It is therefore apparent that as scissors 10 are gradually closed, the cutting point moves along cutting edges 23 and 33 of shearing members 21 and 31 distally of fastener 40 and is preceded by region 101 in which a current flows from one scissor halve to the other to achieve hemostasis of the tissue. Thus, hemostasis occurs at a location just in advance of the cutting point while cutting edges 23 and 33 simultaneously sever the hemostatically heated tissue.

30 The embodiment of FIG. 4 permits an asymmetrical current flow between scissor halves 20 and 30 compared to the embodiment of FIG. 3. Specifically, proximal to the cutting point, some current may flow from the uninsulated shearing surface to tissue in contact with that surface,

through the tissue, and to an uninsulated portion of the other shearing member. The applicant has determined that this asymmetry has no significant effect on the hemostatic cutting operation or the ability of the device to deliver current to the tissue relative to the embodiment of FIG. 3.

Electrically insulating layer 13 is preferably made of a material having a hardness that is greater or substantially greater than the steel or other electrically conducting material used to manufacture conventional scissors-like devices. For example, referring to the embodiment illustrated in FIG. 4, shearing members 21 and 31 may be made of a martensitic stainless steel, e.g., AISI 420. Insulating layer 13 comprises an inorganic electrically insulating material such as a glass, ceramic, nitride, boride or synthetic diamond. Depending upon the material selected, insulating layer 13 may be deposited on shearing surface 32 by conventional techniques, for example, plasma or flame-sprayed deposition. Applicant has obtained good results using ceramic materials such as alumina or zirconia.

The applied coating forms a non-conductive cutting edge for that shearing member and has a greater hardness than the steel substrate and the steel of opposing shearing member 21. Consequently, as coating 13 rubs against the cutting edge 23 or shearing surface 22 of shearing member 21, steel shearing surface 22 and cutting edge 23 are mechanically ground or polished by the harder insulating material 13. Scissors 10 are therefore self-sharpening and remain sharp during continued use. Furthermore, the relatively lower hardness of steel cutting edge 23 will not wear or degrade the insulating characteristics or structure of the harder electrically insulating coating 13, thus providing a durable instrument.

The self-sharpening feature provided by the relatively greater hardness of insulating coating 13 also permits the use of less expensive materials for shearing members 21 and 31. For example, scissors 10 may be made of a material that may not retain a sharp cutting edge during repeated use absent the self-sharpening characteristic of the applied harder coating. This feature is particularly advantageous for constructing scissors 10 to be disposable, or in having disposable shearing members 21 and 31 that detach from their respective support members 25 and 35 (not shown).

Insulating coating 13 is deposited in a layer having a thickness in the range of 0.050 mm (0.002 inches) to about 1.270 mm (0.050 inches), more preferably 0.076 to 0.178 mm (0.003 to 0.007 inches). The applicant has determined that at thicknesses of 0.025 mm (0.001 inch) or less, the thickness of the insulating layer 13 is insufficient to prevent shorting of the electrodes. Insulating layer thicknesses above 0.050 mm (0.002 inches) and below 1.27 mm (0.050 inches) provide adequate hemostasis. It has been observed, however, that the greater the minimum distance between the proximate current conducting portions of the opposing electrodes in the region of current flow through the tissue, the longer the current

path through the tissue and the more difficult it becomes to obtain the desired degree of hemostasis. For the ceramic insulating materials described, insulating layer thicknesses above 1.270 mm (0.050 inches) are believed to be too large for most practical applications.

Referring now to FIG. 5, another embodiment of the scissors of FIG. 1 is described. The scissors, constructed as described hereinbefore with respect to FIG. 3, have a coating 14 of an abherent material disposed on coating 12. The abherent material constituting coating 14 is capable of conducting high frequency current through its thickness and further reduces the sticking and accumulation of blood and tissue to exterior surfaces 24 and 34 of the shearing members. Suitable abherent materials for coating 14 include fluorocarbon material, conductor-filled fluorocarbon coatings or thin fluorocarbon coatings less than about 0.0050 mm (0.0002 inches) thick (which may otherwise be electrically insulating), e.g., Vydex® 1000, available from E.I. duPont de Nemours Company.

FIG. 6 shows yet another embodiment of the bipolar electrosurgical instrument of the present invention. This embodiment is similar to that of FIG. 4, except that exterior surfaces 24 and 34 of shearing members 21 and 31 are provided only with coating 14 of an abherent material and electrically conducting coating 12 is not applied.

Referring now to FIG. 7, another alternative embodiment of the present invention is described. This embodiment is substantially the same as that described hereinbefore with respect to FIG. 4. This embodiment differs, however, in that instead of the electrically conductive coating 12 of the embodiment of FIG. 4, an electrically insulating layer 15 is disposed on exterior surfaces 24 and 34 of shearing members 21 and 31. Layer 15 is omitted from regions 28 and 38 immediately adjacent to cutting edges 23 and 33, respectively. Insulating layer 15 inhibits current flow to the tissue other than through regions 28 and 38 adjacent to cutting edges 23 and 33. Accordingly, heating of the tissue is localized to the region in and preceding the shearing region, thereby reducing joulean heating of tissue proximate to the portions of the exterior surfaces of shearing members 21 and 31 covered by insulating layer 15. Materials suitable for use in insulating layer 15 include aluminum oxide, fluorocarbons, polyamide and silicone based coatings.

Referring to FIG. 8, an embodiment representative of a second family of embodiments constructed in accordance with the present invention is described, with similar components indicated by like-primed members. In this embodiment, which outwardly resembles the scissors of FIG. 1, opposing shearing members 21' and 31' are made of an electrically insulating material, e.g., a ceramic material such as zirconium oxide or aluminum oxide-based ceramics. The exterior surfaces of members 21' and 31', i.e., those portions other than the shearing surfaces 22' and 32' and cutting edges 23' and 33', have a coating 16 comprising a material of high electrical and thermal conductivity, e.g., copper, silver or nickel. Coating 16 thereby provides opposing electrodes for

conduction of high frequency current through tissue between coatings 16 on exterior surfaces 24' and 34' of shearing members 21' and 31'. In this embodiment, coating 16 covers most of the exterior surface of shearing members 21' and 31' such that the current carrying sections closest to cutting edges 23' and 33' are no closer than 0.050 to 1.270 mm (0.002 to 0.050 inches), and more preferably 0.076 to 0.178 mm (0.003 to 0.007 inches). With the configuration of the embodiment of FIG. 8, shearing members 21' and 31' provide the desired insulating material between the electrodes.

EXAMPLES

Scissors in accordance with the embodiments illustrated in FIGS. 1-3 and 4 have been constructed of a martensitic stainless steel material (Grade AISI 420). Scissor halves 20 and 30 were nominally 17.8 cm (seven inches) in length with shearing members 21 and 31 extending 3.8 cm (one and one-half inches) beyond fastener 40. Shearing members 21 and 31 were 2.5 to 7.6 mm (0.1 to 0.3 inches) wide and 1.8 to 2.5 mm (0.07 to 0.10 inches) thick, the smaller dimensions being distal to the pivot. An insulating coating 13 was deposited on shearing surface 32 of shearing member 31 by plasma spraying alumina to a thickness in the range of 0.076 to 0.178 mm (0.003 to 0.007 inches). Coating 13 was applied along the length of member 31 that contacts opposing member 21 in the full range of motion. Using conventional electroplating techniques, exterior surfaces 24 and 34 were provided with a coating 12 of a material having a high electrical and thermal conductivity comprising three layers:

a first layer of copper, 0.05 to 0.076 mm (0.002 to 0.003 inches) thick, was deposited on all surfaces except the shearing surfaces;

a second layer of nickel, 2.5×10^{-4} to 1.02×10^{-3} mm (10 to 40 microinches) thick, was then deposited on the copper layer and;

a third layer of gold, 5.1×10^{-4} to 1.02×10^{-3} mm (20 to 40 microinches) thick, was deposited on the nickel layer. The nickel and gold layers provide an oxidation resistant protective outer layer for the thermally and electrically conductive sublayer of copper. Support members 25 and 35 included a coating 11 of an insulating material about 0.127 mm (0.005 inches) thick.

Experiments were performed on biological tissue and raw beefsteak using the above-described scissors in conjunction with an experimental power supply. The experimental power supply was operated at various selected constant frequencies in the range of 400 to 800 kHz and at selected levels providing a substantially constant voltage output level at the electrodes of the scissors in the range of 10 to 120 volts (RMS). This power supply had a low source impedance, and provided an alternating-current voltage waveform having a crest factor near one. The voltage waveform was maintained at a substantially constant level in the sense that the output voltage did not droop significantly at high loading.

5 The preferred operating range for the above-described embodiment was found to provide a voltage at the electrodes of the instrument of 10-120 volts, more preferably 30-90 volts (RMS). The instrument operated satisfactorily throughout the above range of operating conditions, causing hemostasis of tissue and cutting tissue with minimal bleeding of that tissue. Accumulation of coagulated blood and tissue on the scissors was slight.

10 Frequencies below 100 kHz are known to affect the neuro-muscular systems of the patients, and may cause undesired stimulation. Applicant observed that frequencies above 800 kHz provided no advantage in operation and added cost to the power supply. While applicant believes that it would be possible to use higher frequencies, up to 2 MHz, the line losses in the cable connecting the electrosurgical instrument to the power supply would make use of such frequencies impractical.

15 Applicant observed that voltages (at the electrodes) below 10 volts (RMS) did not produce adequate joulean heating in the tissue to cause hemostasis. While prior art bipolar electrosurgical hemostatic teachings indicated that voltages above 120 volts (RMS) would be most desirable for achieving hemostasis of tissue, applicant observed that voltages above 120 volts (RMS) caused localized overheating of the electrodes and excessive accumulation of coagulum. Above 120 volts (RMS), rapid coagulum buildup necessitated frequent cleaning of the scissors, for example, every one to three cuts.

20 Applicant observed that the device according to FIG. 4, which has coating 13 on only one shearing surface, provides the same level of performance as devices having insulating layers on both shearing surfaces (when operated under the same conditions). For both embodiments, the amount of heating and depth of hemostasis on both sides of the cut tissue are substantially uniform. It will of course be understood by one skilled in the art that use of a voltage level greater than the above specified ranges may be suitable for causing hemostasis in tissue having higher impedance.

25 The scissors of the present invention also can be used for blunt dissection, for example, by spreading the scissors as they are advanced into tissue during the raising of a skin flap. For such an embodiment, the blunt tips of the scissors are configured to cause hemostasis during the blunt dissection procedure. In such a procedure, the scissors are closed when inserted and then gradually opened, causing current flow outward of the cutting point, i.e., so that the dissected tissue is hemostatically severed.

30 The various embodiments described herein are presented for purposes of illustration and not limitation, as the present invention can be practiced with surgical scissors-like instruments of any type or size having two cutting or shearing members movable with respect to one another. Thus, instruments constructed in accordance with the present invention may be adapted for use in cutting surface tissue, deep tissue and internal tissue, vessels, capillaries or organs, as may be required, for

example, in microsurgery, macrosurgery, laparoscopy and other surgical procedures.

Exemplary methods of employing an apparatus having shearing members that include electrodes, wherein operation of the apparatus simultaneously causes hemostasis of tissue and severs that tissue are also provided. As noted in the EXAMPLES provided above, applicant has observed that use of a scissors-like apparatus employing electrodes isolated by an intervening layer of insulating material at frequencies in the range of 400 to 800 kHz and 10 to 120 volts (RMS) provides satisfactory results. One exemplary method of using the apparatus of the present invention, suitable for use in a great variety of surgical procedures, comprises the steps of:

- (a) providing first and second shearing members, each shearing member having a shearing surface, a cutting edge and an electrode, the shearing members connected together so that the shearing surfaces move in opposition through a range of motion in a scissors-like action that defines a cutting point moving along the cutting edges through the range of motion;
- (b) connecting the electrodes to a power supply;
- (c) selecting and maintaining a substantially constant voltage level output across the power supply, the voltage level output independent of the impedance of the load connected across the power supply;
- (d) providing an electrically insulating material between the first and second electrodes so that the electrodes do not contact each other in the range of motion;
- (e) placing the electrodes in electrical contact with tissue to be cut so that high frequency current passes between the electrodes and through the tissue distal to the cutting point, but not between the shearing surfaces; and
- (f) moving the first and second shearing members through the range of motion, thereby passing current through the tissue in a region distal to the cutting point, simultaneously causing hemostasis of the tissue and cutting the tissue at the cutting point.

Of course, it will be apparent to one skilled in the art that steps (a) and (d) described above can be combined by simply providing an apparatus as hereinbefore described. Operation of the apparatus in the range 30 to 90 volts (RMS) will be desirable in many cases, depending upon the impedance of the tissue encountered during the surgical procedure.

The use of a power supply having a selectable substantially constant voltage level output that is independent of load impedance provides sufficient power to cause effective hemostasis. Use of constant voltage output levels lower than those generally used in previously known electrosurgical instruments reduces the power delivered to the electrodes when they are not in contact with tissue, i.e., open-circuited, and reduces the likelihood of gener-

ating a current arc when the electrodes are brought into contact with the tissue.

Use of a constant voltage level output that is independent of the load impedance inhibits excessive current flow through the tissue, as the tissue resistance increases during desiccation. Consequently, the depth of hemostasis obtained in the tissue can be more precisely controlled, and localized overheating of the electrodes better avoided. Reduced localized heating of the electrodes also inhibits coagulum buildup, which can both interfere with efficient hemostasis and impede maneuverability of the instrument.

One skilled in the art will appreciate that the present invention can be practiced by other than the described embodiments, and that the present invention is limited only by the claims which follow.

Claims

20. 1. Apparatus for hemostatically cutting tissue, the apparatus comprising a first support member (25) having a first shearing member (21), a first shearing surface (22) and a first cutting edge (23); a second support member (35) having a second shearing member (31) having a second shearing surface (32) and a second cutting edge (33); and connection means (40) for pivotally joining the first (21) and second (31) shearing members together so that the first (22) and second (32) shearing surfaces face one another and the first cutting edge (23) contacts the second cutting edge (33) as the first shearing member (21) pivots relative to the second shearing member (31) in a scissors-like motion, the connection means (40) comprising an electrically insulative material that electrically isolates the first shearing member (21) from the second shearing member (31) at the connection means (40); characterized in that the first shearing member (21) comprises a composite of an electrically conductive material and a layer (13) of electrically insulative material disposed substantially for the entire length of the first shearing member (21) to electrically isolate the first (21) and second (31) shearing members from one another along their respective lengths when the first (23) and second (33) cutting edges contact each other.
2. The apparatus according to claim 1 characterized in that the layer (13) of electrically insulative material of the first shearing member (21) forms substantially the entire first cutting edge (23) and first shearing surface (22).
3. The apparatus according to claim 2 further characterized in that the layer (13) of electrically insulative material has a hardness that is greater than the hardness of the second cutting edge (33) and the second shearing surface (32).

4. The apparatus according to claim 1 or 2 wherein the layer (13) of electrically insulative material of the first shearing member (21) has a thickness in a range of 0.050 to 1.270 mm (0.002 to 0.050 inches).

5. The apparatus according to claim 4 wherein the layer (13) of electrically insulative material of the first shearing member (21) has a thickness in a range of 0.076 to 0.178 mm (0.003 to 0.007 inches).

6. The apparatus according to any of claims 1 to 5 wherein the layer (13) of the first shearing member (21) has a first thickness and further characterized in that the second shearing member (31) comprises a layer (13) of electrically insulating material having a second thickness and the sum of the first and second thicknesses is selected in a range of from 0.050 to 1.270 mm (0.002 to 0.050 inches).

7. Apparatus according to claim 1 wherein the first shearing member (21) has a portion defining a first electrode (28) extending substantially for the length of the first cutting edge (23) and further characterized in that the second shearing member (31) comprises a composite of an electrically conductive material and a layer (13) of electrically insulative material, the second shearing member having a portion defining a second electrode (38) extending substantially for the length of the second cutting edge (33); the layer (13) of the first shearing member (21) and the layer (13) of the second shearing member (31) electrically isolating the first electrode (28) from the second electrode (38) when the first (23) and second (33) cutting edges contact each other.

8. The apparatus according to claim 7 wherein the layer (13) of the first shearing member (21) has a thickness selected in the range of from 0.050 to 1.270 mm (0.002 to 0.050 inches).

9. The apparatus according to claim 7 wherein the layer (13) of the first shearing member (21) has a first thickness and the layer (13) of the second shearing member (31) has a second thickness and the sum of the first and second thicknesses is selected in a range of from 0.050 to 1.270 mm (0.002 to 0.050 inches).

10. The apparatus according to any of claims 6 to 9 further characterized in that the layer (13) of the first shearing member (21) has a first hardness and the layer (13) of the second shearing member (31) has a second hardness different than the first hardness.

11. The apparatus according to any of claims 1 to 10 characterized in that it further comprises a layer (12) of material having a high electrical and thermal conductivity disposed on at least one of the first (21) and second (31) shearing members.

12. The apparatus according to any of claims 1 to 11 characterized in that it further comprises a layer (14) of electrically conductive adherent material disposed on at least one of the first (21) and second (31) shearing members.

13. The apparatus according to any of claims 1 to 12 wherein the first shearing member (21) further comprises a first support member (20) and the second shearing member (31) further comprises a second support member (30), the first (20) and second (30) support members cooperating with the connection means (40), the first (20) and second (30) support members having a layer (11) of electrically insulating material disposed thereon.

14. The apparatus according to any of claims 1 to 13 in combination with a power supply (110) that provides a high frequency alternating-current waveform, the power supply (110) having a selectable substantially constant voltage level output that is independent of the load impedance, and means (27,37) for electrically connecting the power supply (110) to the first (28) and second (38) electrodes.

15. The apparatus according to claim 14 wherein the substantially constant voltage level output of the power supply (110) is selectable to provide a voltage across the first and second electrodes from the range of 10 to 120 volts (RMS).

16. The apparatus according to claim 14 or 15 wherein the power supply (110) provides a voltage waveform having a crest factor near unity.

17. The apparatus of any of claims 14 to 16 wherein the power supply (110) provides an alternating-current voltage waveform having a high frequency selected from the range of 100 kHz to 2 MHz.

18. Apparatus according to any of claims 1 to 17, for cutting and coagulating tissue, wherein

the first shearing member (21) comprises a first blade member having a portion defining the first shearing surface (22), the first cutting edge (23) having a length, and a first electrode (28) extending substantially for the length of the first cutting edge (23); and the second shearing member (31) comprises a second blade member having a portion defining the second shearing surface (32), the second cutting edge (33) having a length, and a second electrode (38) extending substantially for the length of the second cutting edge (33);

the electrically conductive material of the composite of the first blade member (21) forms the first electrode (28); and

the second blade member (31) comprises an electrically conductive material; and

wherein the layer (13) of electrically insulative

material of the first blade member (21) electrically isolates the first electrode (28) from the second electrode (38) when the first (23) and second (33) cutting edges contact each other.

19. Apparatus for cutting and coagulating tissue, the apparatus comprising a first blade member (21) having a portion defining a first shearing surface (22), a first cutting edge (23) having a length, a first exterior surface (24), and a first electrode extending substantially for the length of the first cutting edge (23); a second blade member (31) having a portion defining a second shearing surface (32), a second cutting edge (33) having a length, a second exterior surface (34) and a second electrode extending substantially for the length of the second cutting edge (33); connection means for pivotally joining the first (21) and second (31) blade members together so that the first (22) and second (32) shearing faces face one another and the first cutting edge (23) contacts the second cutting edge (33) as the first blade member (21) pivots relative to the second blade member (31) in a scissors-like motion; characterized in that

the first blade member (21) comprises an electrically insulative material (21') and the first electrode comprises a first layer (16) of electrically conductive material disposed on the first exterior surface (24); and

the second blade member (31) comprises an electrically insulative material (31') and the second electrode comprises a second layer (16) of electrically conductive material disposed on the second exterior surface (34');

wherein the electrically insulative material of the first blade member (21') and the electrically insulative material of the second blade member (31') electrically isolate the first electrode from the second electrode when the first (23) and second (33) cutting edges contact each other.

20. The apparatus according to claim 19 further comprising a layer of an electrically insulative material disposed on each of the first (16) and second (16) layers of electrically conductive material, except for a first region proximate to the first cutting edge (23) and a second region proximate to the second cutting edge (33).

21. The apparatus according to claim 19 or 20 further comprising a layer of an electrically conductive abherent material disposed in superposition on the first (16) and second (16) layers of electrically conductive material.

22. The apparatus according to any of claims 19 to 21 wherein the first electrode and the second electrode are spaced apart, when the first cutting edge (23) contacts the second cutting edge (33), a distance in

5 a range of from 0.050 to 1.270 mm (0.002 to 0.050 inches).

10 23. The apparatus according to any of claims 19 to 22 in combination with a power supply (110) that provides a high frequency alternating-current waveform, the power supply (110) having a selectable substantially constant voltage level output that is independent of the load impedance, and means (27, 37) for electrically connecting the power supply (110) to the first and second electrodes.

15 24. The apparatus of claim 23 wherein the substantially constant voltage level output of the power supply (110) is selectable to provide a voltage across the first and second electrodes in a range of from 10 to 120 volts (RMS).

20 25. The apparatus of claim 23 or 24 wherein the power supply (110) provides an alternating-current voltage waveform having a frequency selected in a range of from 100 kHz to 2 MHz.

Patentansprüche

25 1. Vorrichtung zum hämostatischen Schneiden von Gewebe, mit einem ersten Stützglied (25), das ein erstes Scherglied (21), eine erste Scherfläche (22) und eine erste Schneidkante (23) aufweist; einem zweiten Stützglied (35), das ein zweites Scherglied (31), eine zweite Scherfläche (32) und eine zweite Schneidkante (33) aufweist; und mit einer Verbindungseinrichtung (40) zum verschwenkbaren Verbinden des ersten (21) mit dem zweiten (31) Scherglied, so daß die erste (22) und die zweite (32) Scherfläche zueinander weisen und die erste Schneidkante (23) die zweite Schneidkante (33) berührt, wenn das erste Scherglied (21) relativ zum zweiten Scherglied (31) in einer scherenartigen Bewegung verschwenkt wird, wobei die Verbindungseinrichtung (40) ein elektrisch isolierendes Material aufweist, das das erste Scherglied (21) vom zweiten Scherglied (31) an der Verbindungseinrichtung (40) elektrisch isoliert, dadurch gekennzeichnet, daß

das erste Scherglied (21) eine Zusammensetzung aus elektrisch leitfähigem Material und einer Schicht (13) aus elektrisch isolierendem Material aufweist, das im wesentlichen über die gesamte Länge des ersten Schergliedes (21) aufgetragen ist, um das erste (21) und das zweite (31) Scherglied voneinander entlang ihrer jeweiligen Länge elektrisch zu isolieren, wenn die erste Schneidkante (23) und die zweite Schneidkante (33) einander berühren.

30 2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Schicht (13) aus elektrisch isolierendem Material des ersten Schergliedes (21) im

35 40 45 50 55

wesentlichen die gesamte erste Schneidkante (23) und die erste Scherfläche (22) bildet.

3. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die Schicht (13) aus elektrisch isolierendem Material eine Härte aufweist, die größer ist als die Härte der zweiten Schneidkante (33) und der zweiten Scherfläche (32). 5

4. Vorrichtung nach Anspruch 1 oder 2, wobei die Schicht (13) aus elektrisch isolierendem Material des ersten Schergliedes (21) eine Dicke im Bereich von 0,050 bis 1,270 mm (0,002 bis 0,050 Inch) aufweist. 10

5. Vorrichtung nach Anspruch 4, wobei die Schicht (13) aus elektrisch isolierendem Material des ersten Schergliedes (21) eine Dicke im Bereich von 0,076 bis 0,178 mm (0,003 bis 0,007 Inch) aufweist. 15

6. Vorrichtung nach einem der Ansprüche 1 bis 5, wobei die Schicht (13) des ersten Schergliedes (21) eine erste Dicke hat und ferner dadurch gekennzeichnet ist, daß das zweite Scherglied (31) eine Schicht (13) aus elektrisch isolierendem Material mit einer zweiten Dicke aufweist, wobei die Summe der ersten und der zweiten Dicke gewählt ist im Bereich von 0,050 bis 1,270 mm (0,002 bis 0,050 Inch). 20

7. Vorrichtung nach Anspruch 1, wobei das erste Scherglied (21) einen Abschnitt aufweist, der eine erste Elektrode (28) definiert, die sich im wesentlichen über die Länge der ersten Schneidkante (23) erstreckt, und dadurch gekennzeichnet, daß das zweite Scherglied (31) eine Zusammensetzung aus einem elektrisch leitfähigen Material und einer Schicht (13) aus elektrisch isolierendem Material aufweist, daß das zweite Scherglied einen Abschnitt aufweist, der eine zweite Elektrode (38) definiert, die sich im wesentlichen über die Länge der zweiten Schneidkante (33) erstreckt, wobei die Schicht (13) des ersten Schergliedes (21) und die Schicht (13) des zweiten Schergliedes (31) die erste Elektrode (28) von der zweiten Elektrode (38) elektrisch isolieren, wenn die erste (23) und die zweite (33) Schneidkanten einander berühren. 25

8. Vorrichtung nach Anspruch 7, wobei die Schicht (13) des ersten Schergliedes (21) eine Dicke im Bereich von 0,050 bis 1,270 mm (0,002 bis 0,050 Inch) aufweist. 30

9. Vorrichtung nach Anspruch 7, wobei die Schicht (13) des ersten Schergliedes (21) eine erste Dicke und die Schicht (13) des zweiten Schergliedes (31) eine zweite Dicke aufweisen, wobei die Summe der ersten und der zweiten Dicke ausgewählt ist im Bereich von 0,050 bis 1,270 mm (0,002 bis 0,050 Inch). 35

10. Vorrichtung nach einem der Ansprüche 6 bis 9, ferner dadurch gekennzeichnet, daß die Schicht (13) des ersten Schergliedes (21) eine erste Härte und die Schicht (13) des zweiten Schergliedes (31) eine zweite Härte aufweisen, die sich von der ersten Härte unterscheidet. 40

11. Vorrichtung nach einem der Ansprüche 1 bis 10, gekennzeichnet durch eine Schicht (12) aus einem Material mit hoher elektrischer und thermischer Leitfähigkeit, die auf mindestens dem ersten (21) und/oder dem zweiten (31) Scherglied aufgebracht ist. 45

12. Vorrichtung nach einem der Ansprüche 1 bis 11, gekennzeichnet durch eine Schicht (14) aus elektrisch leitfähigem, nicht-haftendem Material, das auf dem ersten (21) und/oder dem zweiten (31) Scherglied aufgebracht ist. 50

13. Vorrichtung nach einem der Ansprüche 1 bis 12, wobei das erste Scherglied (21) ferner ein erstes Stützglied (20) und das zweite Scherglied (31) ein zweites Stützglied (30) aufweisen, wobei das erste (20) und das zweite (30) Stützglied mit der Verbindungseinrichtung (40) zusammenwirken, wobei das erste (20) und das zweite (30) Stützglied eine darauf aufgebrachte Schicht (11) aus elektrisch isolierendem Material aufweisen. 55

14. Vorrichtung nach einem der Ansprüche 1 bis 13 in Kombination mit einer Stromversorgung (110) für hochfrequenzen Wechselstrom, wobei die Stromversorgung (110) einen wählbaren, im wesentlichen konstanten Ausgangsspannungspegel unabhängig von der Lastimpedanz hat, und mit einer Einrichtung (27, 37) zum elektrischen Verbinden der Stromversorgung (110) mit der ersten (28) und der zweiten (38) Elektrode. 60

15. Vorrichtung nach Anspruch 14, wobei die im wesentlichen konstante Ausgangsspannung der Stromversorgung (110) einstellbar ist, um eine Spannung über die ersten und die zweiten Elektroden im Bereich von 10 bis 120 Volt (RMS) bereitzustellen. 65

16. Vorrichtung nach Anspruch 14 oder 15, wobei die Stromversorgung (110) eine Spannungswellenform mit einem Spitzenfaktor nahe bei 1 bereitstellt. 70

17. Vorrichtung nach einem der Ansprüche 14 bis 16, wobei die Stromversorgung (110) eine Wechselstrom-Spannungswellenform mit einer Hochfrequenz im Bereich von 100 kHz bis 2MHz bereitstellt. 75

18. Vorrichtung nach einem der Ansprüche 1 bis 17 zum Schneiden und Koagulieren von Gewebe, wobei das erste Scherglied (21) ein erstes Schneidglied mit einem Abschnitt aufweist, der eine erste Scher- 80

fläche (22) definiert, wobei die erste Schneidkante (23) eine Längenerstreckung hat und die erste Elektrode (28) sich im wesentlichen über die Länge der ersten Schneidkante (23) erstreckt, und das zweite Scherglied (31) ein zweites Schneidglied mit einem Abschnitt aufweist, der eine zweite Scherfläche (32) definiert, die zweite Schneidkante (33) sich über eine Länge erstreckt und eine zweite Elektrode (38) sich im wesentlichen über die Länge der zweiten Schneidkante (33) erstreckt, das elektrisch leitfähige Material der Zusammensetzung des ersten Schneidgliedes (21) die erste Elektrode (28) bildet, und das zweite Schneidglied (31) ein elektrisch leitfähiges Material aufweist, wobei die Schicht (13) aus elektrisch isolierendem Material des ersten Schneidgliedes (21) die erste Elektrode (28) von der zweiten Elektrode (38) elektrisch isoliert, wenn die erste Schneidkante (23) und die zweite Schneidkante (33) einander berühren.

19. Vorrichtung zum Schneiden und Koagulieren von Gewebe, mit einem ersten Schneidglied (21) mit einem Abschnitt, der eine erste Scherfläche (22) definiert, einer ersten Schneidkante (23) mit einer Länge, einer ersten Außenfläche (24) und mit einer ersten Elektrode, die sich im wesentlichen über die Länge der ersten Schneidkante (23) erstreckt, ein zweites Schneidglied (31) mit einem Abschnitt, der eine zweite Scherfläche (32) definiert, einer zweiten Schneidkante (33) mit einer Länge, einer zweiten Außenfläche (34) und einer zweiten Elektrode, die sich im wesentlichen über die Länge der zweiten Schneidkante (33) erstreckt, einer Verbindungseinrichtung zum verschwenkbaren Verbinden des ersten (21) und des zweiten (31) Schneidgliedes miteinander, so daß die erste (22) und die zweite (32) Scherfläche zueinander weisen und die erste Schneidkante (23) die zweite Schneidkante (33) berührt, wenn das erste Schneidglied (21) relativ zum zweiten Schneidglied (31) in einer scherenartigen Bewegung verschwenkt wird, dadurch gekennzeichnet, daß das erste Schneidglied (21) ein elektrisch isolierendes Material (21) aufweist und die erste Elektrode eine erste Schicht (16) aus elektrisch leitfähigem Material aufweist, das auf der ersten Außenfläche (24) aufgebracht ist, und das zweite Schneidglied (31) ein elektrisch isolierendes Material (31) aufweist und die zweite Elektrode eine zweite Schicht (16) aus elektrisch leitfähigem Material aufweist, das auf der zweiten Außenfläche (34) aufgebracht ist, wobei das elektrisch isolierende Material des ersten Schneidgliedes (21) und das elektrisch isolierende Material des zweiten Schneidgliedes (31) die erste Elektrode von der zweiten Elektrode elektrisch isolieren, wenn die erste Schneidkante (23) und die zweite Schneidkante (33) einander berühren.

5 20. Vorrichtung nach Anspruch 19, ferner mit einer Schicht aus elektrisch isolierendem Material, das auf jeder der ersten (16) und zweiten (16) Schicht aus elektrisch leitfähigem Material aufgebracht ist, mit der Ausnahme eines ersten Bereichs, der sich in der Nähe zur ersten Schneidkante (23) befindet, und eines zweiten Bereichs, der sich in der Nähe zu der zweiten Schneidkante (33) befindet.

10 21. Vorrichtung nach Anspruch 19 oder 20, ferner mit einer Schicht aus elektrisch leitfähigem, nicht haftendem Material, das überlagert auf der ersten (16) und der zweiten (16) Schicht aus elektrisch leitendem Material aufgebracht ist.

15 22. Vorrichtung nach einem der Ansprüche 19 bis 21, wobei die erste Elektrode und die zweite Elektrode voneinander beabstandet sind, wenn die erste Schneidkante (23) die zweite Schneidkante (33) berührt, in einem Abstand im Bereich von 0,050 bis 1,270 mm (0,002 bis 0,050 Inch).

20 23. Vorrichtung nach einem der Ansprüche 19 bis 22, in Kombination mit einer Stromversorgung (110), die eine Hochfrequenz-Wechselstrom-Wellenform bereitstellt, wobei die Stromversorgung (110) eine einstellbare, im wesentlichen konstante Ausgangsspannung unabhängig von der Lastimpedanz hat, und mit einer Einrichtung (27, 37) zum elektrischen Verbinden der Stromversorgung (110) mit der ersten und der zweiten Elektrode.

25 24. Vorrichtung nach Anspruch 23, wobei der im wesentlichen konstante Ausgangsspannungsspeicher der Stromversorgung (110) einstellbar ist zum Bereitstellen einer Spannung zwischen der ersten und der zweiten Elektrode im Bereich von 10 bis 120 Volt (RMS).

30 25. Vorrichtung nach Anspruch 23 oder 24, wobei die Stromversorgung (110) eine Wechselstrom-Spannungswellenform mit einer Frequenz im Bereich von 100 kHz bis 2 MHz bereitstellt.

35 45 Revendications

50 1. Appareil pour couper hémostatiquement un tissu, cet appareil comprenant un premier élément de support (25) comportant un premier élément de cisaillement (21), une première surface de cisaillement (22) et un premier bord de coupe (23) ; un second élément de support (35) comportant un second élément de cisaillement (31) ayant une seconde surface de cisaillement (32) et un second bord de coupe (33) ; et des moyens de liaison (40) pour relier en pivotement le premier élément de cisaillement (21) et le second élément de cisaillement (31) l'un à l'autre de façon que la première surface de cisaillement (22) et la seconde surface de cisaillement (32)

viennent en face l'une de l'autre et que le premier bord de coupe (23) vienne en contact avec le second bord de coupe (33) lorsque le premier élément de cisaillement (21) pivote par rapport au second élément de cisaillement (31) dans un mouvement de ciseaux, les moyens de liaison (40) comprenant un matériau électriquement isolant qui isole électriquement le premier élément de cisaillement (21) du second élément de cisaillement (31) à l'endroit des moyens de liaison (40), caractérisé en ce que le premier élément de cisaillement (21) comprend un composé d'un matériau électriquement conducteur et d'une couche (13) d'un matériau électriquement isolant disposée essentiellement sur toute la longueur du premier élément de cisaillement (21), pour isoler électriquement le premier élément de cisaillement (21) et le second élément de cisaillement (31) l'un de l'autre suivant leurs longueurs respectives lorsque le premier bord de coupe (23) et le second bord de coupe (33) viennent en contact l'un avec l'autre.

2. Appareil selon la revendication 1, caractérisé en ce que la couche (13) du matériau électriquement isolant du premier élément de cisaillement (21) forme essentiellement tout le premier bord de coupe (23) et toute la première surface de cisaillement (22).

3. Appareil selon la revendication 2, caractérisé en outre en ce que la couche (13) du matériau électriquement isolant présente une dureté supérieure à celle du second bord de coupe (33) et de la seconde surface de cisaillement (32).

4. Appareil selon la revendication 1 ou 2, caractérisé en ce que la couche (13) de matériau électriquement isolant du premier élément de cisaillement (21) a une épaisseur se situant dans une plage de 0,050 à 1,270 mm (0,002 à 0,050 pouce).

5. Appareil selon la revendication 4, caractérisé en ce que la couche (13) de matériau électriquement isolant du premier élément de cisaillement (21) a une épaisseur se situant dans une plage de 0,076 à 0,178 mm (0,003 à 0,007 pouce).

6. Appareil selon l'une quelconque des revendications 1 à 5, dans lequel la couche (13) du premier élément de cisaillement (21) présente une première épaisseur, et caractérisé en outre en ce que le second élément de cisaillement (31) comprend une couche (13) d'un matériau électriquement isolant présentant une seconde épaisseur, la somme de la première épaisseur et de la seconde épaisseur étant choisie dans une plage se situant de 0,050 à 1,270 mm (0,002 à 0,050 pouce).

7. Appareil selon la revendication 1, caractérisé en ce que le premier élément de cisaillement (21) com-

porte une partie définissant une première électrode (28) s'étendant essentiellement sur toute la longueur du premier bord de coupe (23), et caractérisé en outre en ce que le second élément de cisaillement (31) comprend un composé d'un matériau électriquement conducteur et d'une couche (13) de matériau électriquement isolant, le second élément de cisaillement comportant une partie définissant une seconde électrode (38) s'étendant essentiellement sur toute la longueur du second bord de coupe (33) ; la couche (13) du premier élément de cisaillement (21) et la couche (13) du second élément de cisaillement (31) isolant électriquement la première électrode (28) de la seconde électrode (38) lorsque le premier bord de coupe (23) et le second bord de coupe (33) viennent en contact l'un avec l'autre.

8. Appareil selon la revendication 7, caractérisé en ce que la couche (13) du premier élément de cisaillement (21) a une épaisseur sélectionnée dans la plage de 0,050 à 1,270 mm (0,002 à 0,050 pouce).

9. Appareil selon la revendication 7, caractérisé en ce que la couche (13) du premier élément de cisaillement (21) présente une première épaisseur, tandis que la couche (13) du second élément de cisaillement (31) présente une seconde épaisseur, la somme de la première épaisseur et de la seconde épaisseur étant sélectionnée dans une plage se situant de 0,050 à 1,270 mm (0,002 à 0,050 pouce).

10. Appareil selon l'une quelconque des revendications 6 à 9, caractérisé en outre en ce que la couche (13) du premier élément de cisaillement (21) présente une première dureté tandis que la couche (13) du second élément de cisaillement (31) présente une seconde dureté différente de la première dureté.

11. Appareil selon l'une quelconque des revendications 1 à 10, caractérisé en ce qu'il comprend en outre une couche (12) d'un matériau présentant une grande conductibilité électrique et thermique, cette couche (12) étant disposée sur l'un au moins du premier élément de cisaillement (21) et du second élément de cisaillement (31).

12. Appareil selon l'une quelconque des revendications 1 à 11, caractérisé en ce qu'il comprend en outre une couche (14) d'un matériau non-adhérent, électriquement conducteur, cette couche (14) étant disposée sur l'un au moins du premier élément de cisaillement (21) et du second élément de cisaillement (31).

13. Appareil selon l'une quelconque des revendications 1 à 12, caractérisé en ce que le premier élément de cisaillement (21) comprend en outre un premier élément de support (20) tandis que le second élément de cisaillement (31) comprend en outre un second

élément de support (30), le premier élément de support (20) et le second élément de support (30) coïncidant avec les moyens de liaison (40), le premier élément de support (20) et le second élément de support (30) comportant une couche (11) de matériau électriquement isolant disposée sur ceux-ci.

14. Appareil selon l'une quelconque des revendications 1 à 13 en combinaison avec une alimentation de puissance (110) fournissant une forme d'onde de courant alternatif haute fréquence, cette alimentation de puissance (110) présentant un niveau de tension de sortie essentiellement constant, sélectionnable, qui est indépendant de l'impédance de la charge, et des moyens (27, 37) pour brancher électriquement l'alimentation de puissance (110) à la première électrode (28) et à la seconde électrode (38).

15. Appareil selon la revendication 14, caractérisé en ce que le niveau de tension de sortie essentiellement constant de l'alimentation de puissance (110) est sélectionnable pour fournir, aux bornes de la première et seconde électrode, une tension se situant dans la plage de 10 à 120 volts (RMS).

16. Appareil selon la revendication 14 ou 15, caractérisé en ce que l'alimentation de puissance (110) fournit une forme d'onde de tension ayant un facteur de crête voisin de l'unité.

17. Appareil selon l'une quelconque des revendications 14 à 16, caractérisé en ce que l'alimentation de puissance (110) fournit une forme d'onde de tension en courant alternatif présentant une haute fréquence sélectionnée dans la plage de 100 kHz à 2 MHz.

18. Appareil selon l'une quelconque des revendications 1 à 17, pour couper et coaguler un tissu, dans lequel

- le premier élément de cisaillement (21) comprend un premier élément de lame muni d'une partie définissant la première surface de cisaillement (22), le premier bord de coupe (23) ayant une certaine longueur, et une première électrode (28) s'étendant essentiellement sur toute la longueur du premier bord de coupe (23) ; et le second élément de cisaillement (31) comprend un second élément de lame muni d'une partie définissant la seconde surface de cisaillement (32), le second bord de coupe (33) ayant une certaine longueur, et une seconde électrode (38) s'étendant essentiellement sur toute la longueur du second bord de coupe (33) ;
- le matériau électriquement conducteur du composé du premier élément de lame (21) forme la première électrode (28) ; et

- le second élément de lame (31) est constitué d'un matériau électriquement conducteur ; et

dans lequel la couche (13) de matériau électriquement isolant du premier élément de lame (21) isole électriquement la première électrode (28) de la seconde électrode (38) lorsque le premier bord de coupe (23) et le second bord de coupe (33) viennent en contact l'un avec l'autre.

19. Appareil pour couper et coaguler un tissu, cet appareil comprenant un premier élément de lame (21) comportant une partie définissant une première surface de cisaillement (22), un premier bord de coupe (23) ayant une certaine longueur, une première surface extérieure (24), et une première électrode s'étendant essentiellement sur toute la longueur du premier bord de coupe (23) ; un second élément de lame (31) comportant une partie définissant une seconde surface de cisaillement (32), un second bord de coupe (33) ayant une certaine longueur, une seconde surface extérieure (34) et une seconde électrode s'étendant essentiellement sur toute la longueur du second bord de coupe (33) ; des moyens de liaison pour relier en pivotement le premier élément de lame (21) au second élément de lame (31) de façon que la première surface de cisaillement (22) et la seconde surface de cisaillement (32) viennent l'une en face de l'autre, et que le premier bord de coupe (23) vienne en contact avec le second bord de coupe (33) lorsque le premier élément de lame (21) pivote par rapport au second élément de lame (31) dans un mouvement de ciseaux, caractérisé en ce que :

- le premier élément de lame (21) comprend un matériau électriquement isolant (21') tandis que la première électrode comprend une première couche (16) de matériau électriquement conducteur disposée sur la première surface extérieure (24') ; et
- le second élément de lame (31) comprend un matériau électriquement isolant (31') tandis que la seconde électrode comprend une seconde couche (16) de matériau électriquement conducteur disposée sur la seconde surface extérieure (34') ;
- le matériau électriquement isolant du premier élément de lame (21) et le matériau électriquement isolant du second élément de lame (31) isolent électriquement la première électrode de la seconde électrode lorsque le premier bord de coupe (23) et le second bord de coupe (33) viennent en contact l'un avec l'autre.

20. Appareil selon la revendication 19, caractérisé en ce qu'il comprend en outre une couche d'un matériau électriquement isolant disposée sur chacune de la première couche (16) et de la seconde couche (16)

de matériau électriquement conducteur, sauf dans une première zone proche du premier bord de coupe (23) et dans une seconde zone proche du second bord de coupe (33).

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21. Appareil selon la revendication 19 ou 20, caractérisé en ce qu'il comprend en outre une couche d'un matériau non-adhérent, électriquement conducteur, disposée en superposition sur la première couche (16) et sur la seconde couche (16) de matériau électriquement conducteur. 10

22. Appareil selon l'une quelconque des revendications 19 à 21, caractérisé en ce que la première électrode et la seconde électrode sont espacées l'une de l'autre d'une distance se situant dans une plage de 0,050 à 1,270 mm (0,002 à 0,050 pouce) lorsque le premier bord de coupe (23) vient en contact avec le second bord de coupe (33). 15

23. Appareil selon l'une quelconque des revendications 19 à 22, en combinaison avec une alimentation de puissance (110) fournissant une forme d'onde de courant alternatif haute fréquence, cette alimentation de puissance (110) présentant un niveau de tension de sortie essentiellement constant, sélectionnable, qui est indépendant de l'impédance de la charge, et des moyens (27, 37) pour brancher électriquement l'alimentation de puissance (110) à la première électrode et à la seconde électrode. 20 25 30

24. Appareil selon la revendication 23, caractérisé en ce que le niveau de tension de sortie essentiellement constant de l'alimentation de puissance (110) est sélectionnable pour fournir, aux bornes de la première électrode et de la seconde électrode, une tension se situant dans une plage de 10 à 120 volts (RMS). 35

25. Appareil selon la revendication 23 ou 24, caractérisé en ce que l'alimentation de puissance (110) fournit une forme d'onde de tension en courant alternatif ayant une fréquence sélectionnée dans une plage se situant de 100 kHz à 2 MHz. 40

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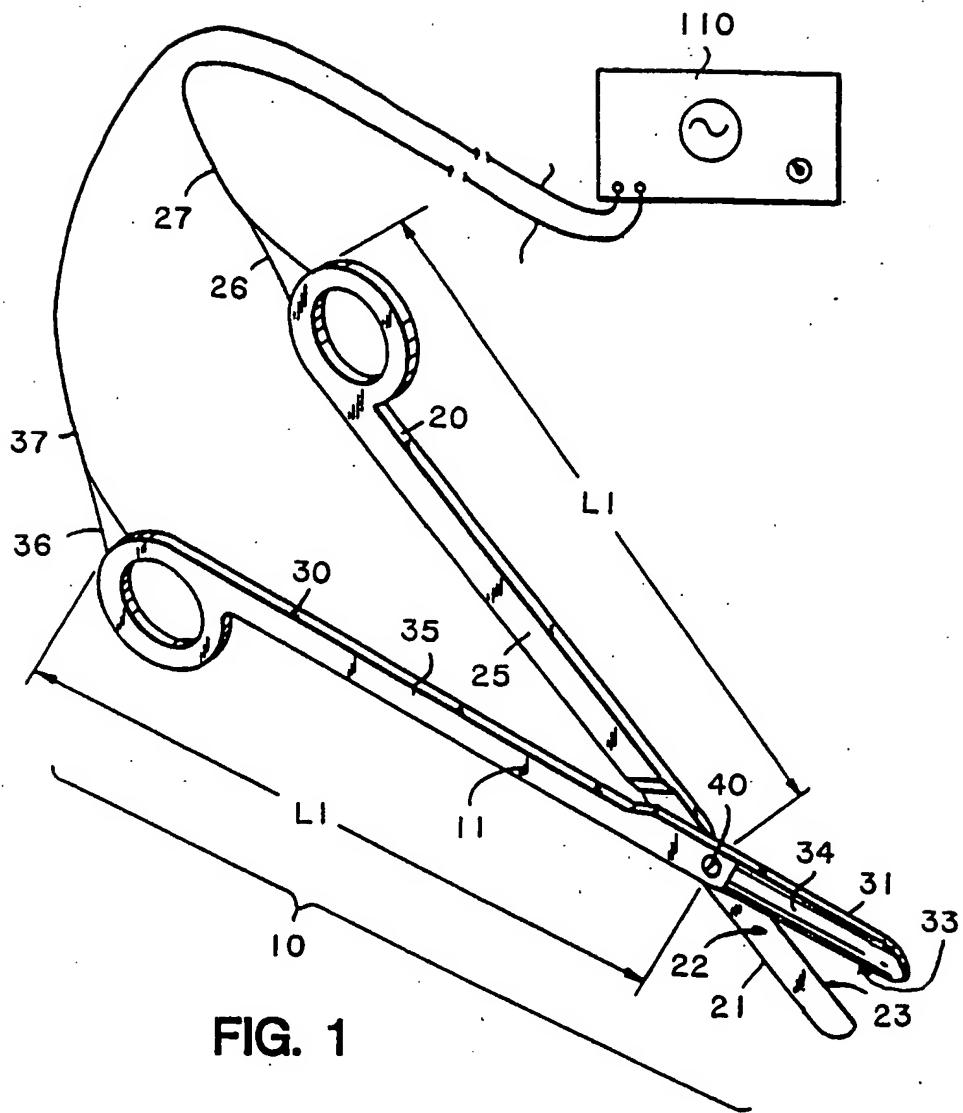


FIG. 1

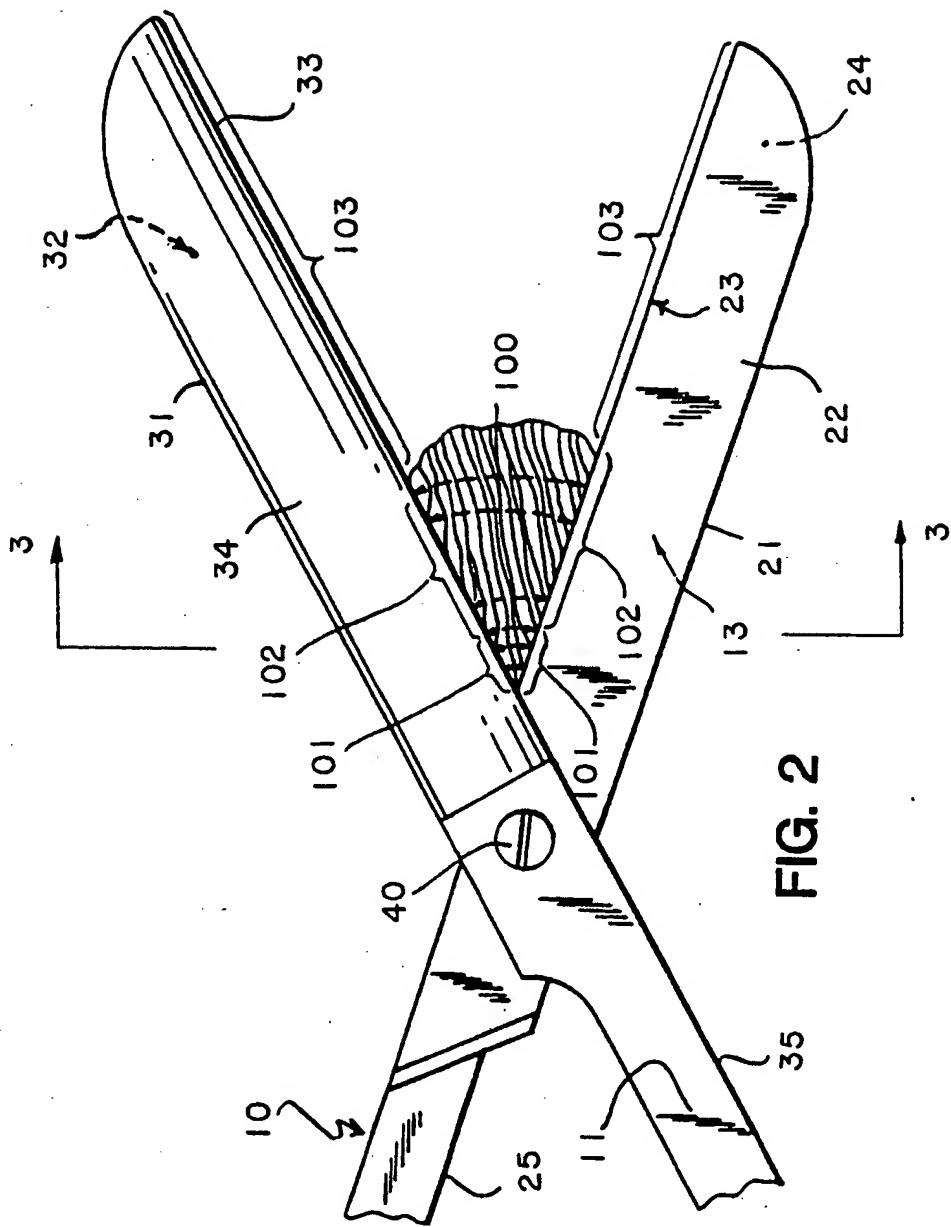


FIG. 2

FIG. 3

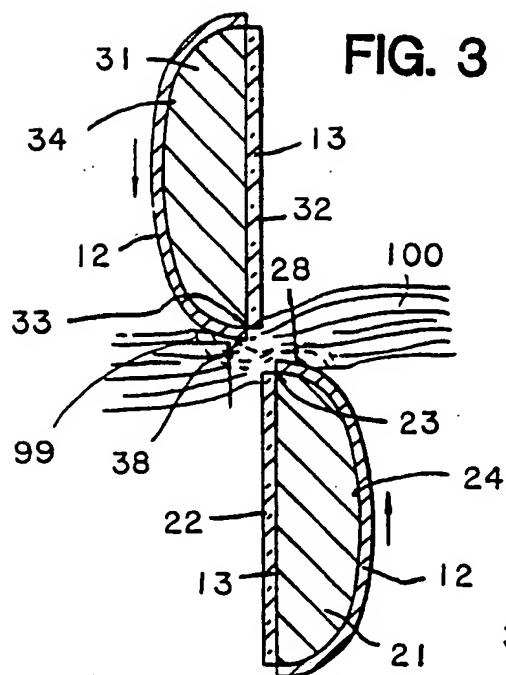


FIG. 5

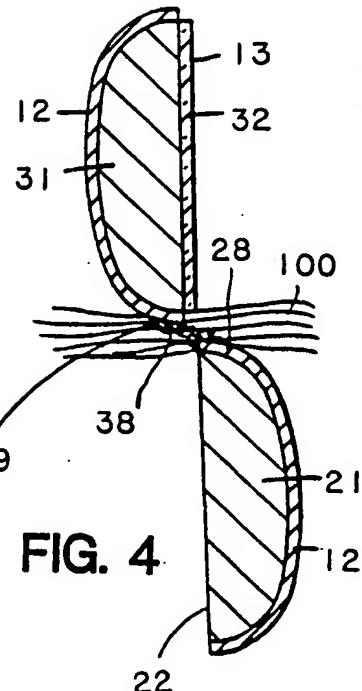
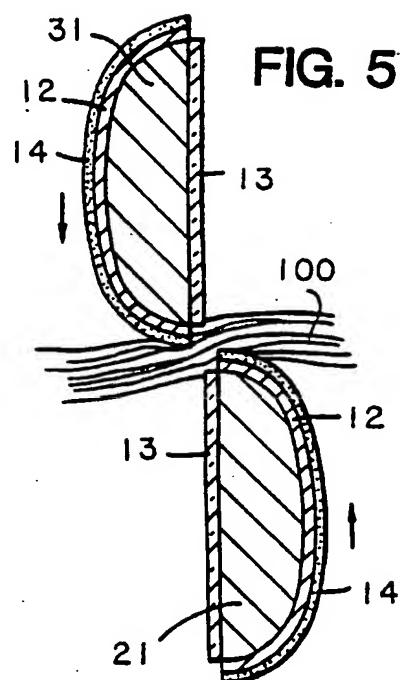


FIG. 4

FIG. 6

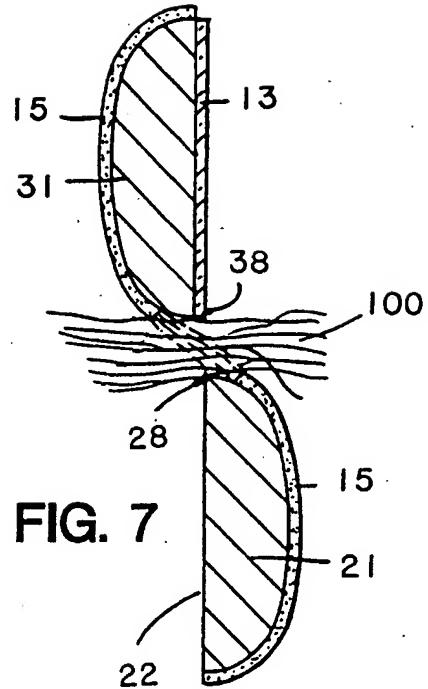
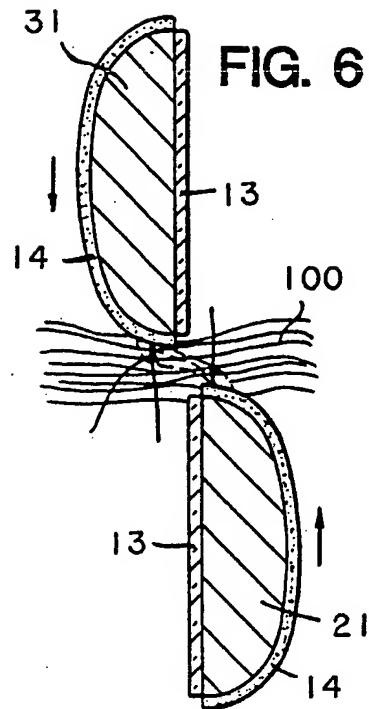


FIG. 8

